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**NASA TECHNICAL  
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NASA TM X-62,105

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**ADVANCED CONCEPTS & MISSIONS DIVISION PUBLICATIONS - 1971**

**By Staff**

**Office of Advanced Research and Technology  
Advanced Concepts & Missions Division  
Moffett Field, California 94035**


**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
WASHINGTON, D. C.                      DECEMBER 1971**

PUBLICATIONS - 1971

Staff of the Advanced Concepts & Missions Division

December 1971

Approved: \_\_\_\_\_

  
Deputy Director  
Advanced Concepts & Missions Division

Advanced Concepts & Missions Division  
Office of Advanced Research and Technology  
National Aeronautics and Space Administration

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## FOREWORD

This document is part of a series of annual papers on Advanced Concepts and Missions Division (ACMD) publications. It contains a bibliography and corresponding abstract of all papers presented or published by personnel of ACMD during the calendar year 1971. Also included are abstracts of final reports of ACMD contracted studies performed during this time period.

The bibliography is presented in Part I of this paper. Within each category shown in the Table of Contents, the listings are in reverse chronological order according to the earliest date of publication or presentation. The abstracts are given in Part II and are presented in the same order as the bibliography listings.

Documents reporting publications during prior years are also available upon request. Requests should be made directly to the Advanced Concepts and Missions Division Office at Moffett Field, California.

PART I - BIBLIOGRAPHY

## AERONAUTICAL MISSIONS

### Aeronautical Systems

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January 1971.

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### General

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PART II - ABSTRACTS

AERONAUTICAL MISSIONS

NOISE, COST, AND PERFORMANCE CONSIDERATIONS  
OF ADVANCED GENERAL AVIATION PROPELLERS

Contract NAS 2-5885

Advanced General Aviation Propeller Study - CR 114289

Technical Monitor  
Program Manager

Mark H. Waters  
Rose Worobel  
Millard G. Mayo

Hamilton Standard  
Division of United Aircraft Corporation  
Windsor Locks, Connecticut

April 1971

Abstract

Methods for predicting the performance, noise, weight, and cost of propellers for advanced general aviation aircraft of the 1980 time period were developed and computerized. A propeller sensitivity study based on the computer program is presented for five representative general aviation aircraft. Conceptual design studies are included for three propellers selected from the sensitivity studies to check the weight and cost estimating procedures. Problem areas exist in the methodology defined and follow-on studies are recommended. A listing of the computer program is presented.

# ESTIMATED AERODYNAMICS OF ALL-BODY HYPERSONIC AIRCRAFT CONFIGURATIONS

Louis J. Williams

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

The results of analyses for estimating the aerodynamics of a representative family of all-body hypersonic aircraft configurations are presented. The configuration body shape is a delta planform with an elliptical cone forebody and an elliptical cross-section afterbody. Semiempirical and theoretical predictions of the aerodynamic characteristics of the forebody are compared with available experimental data to show the reliability of the basic methods. Results are presented for aerodynamic performance, surface temperatures, and static longitudinal and directional stability. Aerodynamic performance of the all-body configurations is presented in the form of the effect on complete configuration maximum lift-to-drag ratio of Mach number, configuration geometry, and maximum allowable leading-edge temperature. Variations in the basic all-body shape were investigated using three independent shape parameters; body leading-edge sweep, position of breakpoint between forebody and afterbody, and ratio of maximum cross section to body planform area. The third shape parameter had the strongest influence on the aerodynamic performance. Studies of the radiation equilibrium surface temperature show that the temperatures on the lower surface resulting from the inherent low lift loading of the all-body configuration are less than would be expected for higher lift-loading configurations. A brief analysis of vehicle stability and control showed that using a canard for trim instead of horizontal fins reduced trim drag penalties.

NASA TM X-2091, March 1971

# TURBOJET-RAMJET PROPULSION SYSTEM FOR ALL-BODY HYPERSONIC AIRCRAFT

Mark H. Waters

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

The characteristics of a parallel, over-and-under, turbojet-ramjet propulsion system installed on an all-body Mach number 6 hypersonic aircraft are estimated, and the effects of variations in propulsion system parameters on payload and on problems of installation are determined. Engine thrust and fuel flow requirements are evaluated throughout acceleration and cruise, and the effects on the weights and dimensions of the propulsion system, including both inlets and engines, are determined. A wraparound turbo-ramjet is also evaluated and comparisons with the parallel turbojet-ramjet system are made.

NASA TN D-5993, January 1971

## ASSESSMENT OF STOL STUDIES

John Riebe (LaRC)  
Robert Denington (LeRC)  
John Gibbons (FRC)  
George Kenyon (OART/ACMD)  
Elwood Stewart (ARC)

National Aeronautics and Space Administration

### Abstract

A study committee consisting of representatives from OART's Advanced Concepts and Missions Division and from Ames, Langley, Lewis and Flight Research Centers was convened the week of October 26, 1971 to assess the STOL System Studies literature and develop an integrated position on the state of STOL knowledge and the need for further STOL System Studies. The review covered STOL technology and transportation systems that used STOL aircraft operating from CTOL airports as well as new STOLports. The systems were generally assumed to be operating in the 1975-1985 time period. A bibliography of the more pertinent sources is included. It is concluded that further STOL system studies are required.

Working Paper MA 71-6, December 1971



# EMPTY WEIGHT AND GROSS WEIGHT ESTIMATIONS OF COMMERCIAL TRANSPORT AIRCRAFT

Joseph L. Anderson

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

In evaluating current or proposed commercial transport airplanes, there has not been available a ready means to determine weights so as to compare airplanes within this particular class. This paper describes the development of and presents such a comparative tool. The major design characteristics of existing American transport airplanes were collected and these data were correlated by means of regression analysis to develop weight relationships for these airplanes as functions of their operational requirements. The characteristics for 66 airplanes were assembled and examined in terms of the effects of the number of people carried, the range, and the cruise speed. These airplane characteristics were correlated for all the airplanes as a single class, and for each of five sub-classes, ranging from piston engine transports to the new wide-body jets.

Working Paper MA 71-5, November 1971

# COMPUTER PROGRAM FOR ESTIMATING COMMERCIAL AIRCRAFT RETURN ON INVESTMENT

Eric E. Anderson

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

This paper describes a computer program which was written to provide a comprehensive analysis of the economic productivity of commercial aircraft. The program utilizes the discounted cash flow concept to measure the ability of the aircraft to return the initial investment together with interest over a specified life span. The program calculates net earnings, net cash flow, and discounted cash flow, thus giving an internal rate of return (discounted cash flow return on investment) which can be tailored to a variety of individual considerations, since various revenue amounts, operating costs, depreciation schedules, financing arrangements, and interest rates can be specified. It provides a description of the economic model and includes a listing of the computer program, sample input and output, and a definition of the parameters used.

Working Paper MA 71-4, October 1971

# HYPERSONIC RESEARCH FACILITIES STUDY

Contract NAS 2-5458

Volume I	- Summary .....	CR 114322
Volume II	- Phase I Preliminary Studies	
	Part I - Research Requirements and Ground Facility Synthesis .....	CR 114323
	Part 2 - Flight Vehicle Synthesis .....	CR 114324
Volume III	- Phase II Parametric Studies	
	Part 1 - Research Requirements and Ground Facility Synthesis .....	CR 114325
	Part 2 - Flight Vehicle Synthesis .....	CR 114326
Volume IV	- Phase III Final Studies	
	Part 1 - Flight Research Vehicles .....	CR 114327
	Part 2 - Ground Research Facilities .....	CR 114328
	Part 3 - Research Requirements Analysis and Facility Potential .....	CR 114329
Volume V	- Limited Rights Data .....	CR 114330
Volume VI	- Operational System Characteristics .....	CR 114331

Technical Monitor  
Program Manager

Richard H. Petersen  
Charles J. Pirrello

McDonnell Aircraft Company  
St. Louis, Missouri

August 1971

## Abstract

The primary objective of the contract was to assess the research and development requirements for hypersonic aircraft and, based on these requirements, to provide the NASA with descriptions of a number of desirable hypersonic research facilities and estimates of their performance, costs, development time schedules, and research capabilities. A secondary objective was to identify any areas in which the NASA should intensify or reorient its present hypersonic research program in order to contribute to the development of such facilities. Specific areas of emphasis included: (1) identification of the necessary research associated with a group of operational systems; (2) evaluation of methods of accomplishing the necessary research through a ground test program and through a flight test program; and (3) analysis of the capability and costs of various conceptual ground facilities and flight research vehicles.

# A COMPUTER MODEL OF TRAFFIC FLOW THROUGH A STOL AIR TERMINAL FACILITY

Robert E. Rinker

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

Presented is a computer model of the terminal traffic flow through a proposed STOL air terminal. The model uses both Fortran IV and GPSS languages. The model can be used to predict traffic flow patterns and easily identify potential bottlenecks. The model can also be used to predict the effects of changing terminal facilities (i. e., number of passenger gates) and of changing the air traffic control rules used in the terminal area (i. e., minimum allowable approach spacing). The program is designed to be used by a user with a little knowledge of Fortran and no knowledge of GPSS.

Working Paper MA 71-1, June 1971

TECHNOLOGY ASSESSMENT OF ADVANCED GENERAL  
AVIATION AIRCRAFT

Contract NAS 2-5972

Summary Report - CR 114338

Final Report - CR 114339

Technical Monitor  
Program Manager

Thomas L. Galloway  
C. H. Hurkamp

Lockheed-Georgia Company  
Marietta, Georgia

June 1971

- Abstract

This contract assessed the impact of technology applicable to advanced general aviation aircraft of the 1985 time period. An important facet of the study was to determine the influence of advanced technology and new design philosophies on the cost, performance, and operational capabilities of this class of aircraft. Four categories of aircraft encompassing conventional, STOL, and V/STOL performance were investigated. The areas of technology included aerodynamics, propulsion, structural materials, avionics, flight safety, automatic control, and noise. These areas were assessed individually and in combination and their potential impact determined in the four categories of aircraft.

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AIRBREATHING LAUNCH VEHICLE FOR EARTH ORBIT  
SHUTTLE--PERFORMANCE AND OPERATION

\*\*Thomas J. Gregory  
\*Louis J. Williams  
\*Darrell E. Wilcox

\*NASA, Advanced Concepts & Missions Division  
Moffett Field, California

\*\*NASA, Ames Research Center  
Moffett Field, California

Abstract

Reusable launch vehicles with both airbreathing and rocket-powered first stages are analyzed and their performance, costs, and operational characteristics are compared. The results suggest that the airbreathing systems have lower gross weight and slightly lower dry weight for the same mission. Operationally, the airbreathing systems offer several advantages, such as airplane-type takeoff and landing from conventional airfields, intact abort without staging, launch into offset orbits, and substantial ferry range. The total system costs of the rocket and air-breathing systems are similar but the airbreathing system requires more development time. The technology required to develop the airbreathing launch vehicle is similar to that of any reusable shuttle vehicle with the exception of the propulsion system. A companion paper reviews recent technological progress for the airbreathing system with special emphasis on propulsion.

Published in Journal of Aircraft, Vol. 8, No. 9, pp. 724-731, September 1971

# AIRCRAFT IN INTRAURBAN TRANSPORTATION SYSTEMS

Contract NAS 2-5989

Final Report - Summary

Volume I - Phase I - Aircraft Concepts Selection (CR 114340)

Volume II - Phase I - Aircraft Concepts Selection (CR 114341)

Volume III - Phase II - Aircraft Concepts Evaluation (CR 114342)

Volume IV - Appendix (CR 114343)

Technical Monitor  
Program Manager

George C. Kenyon  
E. G. Stout

Lockheed-California Company  
Burbank, California

June 1971

## Abstract

A systems analysis was conducted to define the technical, economic, and operational characteristics of an aircraft transportation system for short range intercity commuter operations. The analysis was for 1975 and 1985 in the seven county Detroit, Michigan area. STOL and VTOL aircraft were studied in sizes from 40 to 120 passengers. The preferred vehicle for the Detroit area was the deflected slipstream STOL. Since the study was parametric in nature, it is applicable to generalization; and it was concluded that a feasible intraurban air transportation system could be developed in many viable situations.



# AIRCRAFT IN INTRAURBAN TRANSPORTATION SYSTEMS

Contract NAS 2-5969

Summary Report - CR 2006

Final Report - CR 114347

Technical Monitor  
Program Manager

George C. Kenyon  
C. R. Rushmer

The Boeing Company  
Renton, Washington

March 1971

## Abstract

The contract examines the nine-county San Francisco Bay Area in two time periods (1975-1980 and 1985-1990) as a scenario for analyzing the characteristics of an intraurban, commuter-oriented aircraft transportation system. Aircraft have dominated the long-haul passenger market for some time, but efforts to penetrate the very-short-haul intraurban market have met with only token success. Yet, the characteristics of an aircraft transportation system--speed and flexibility--are very much needed to solve the transportation ills of our major urban areas. The aircraft intra-urban system is a technically feasible alternative to ground transportation systems. Although requiring some subsidy, it becomes socially viable where substantial commuter traffic exists at ranges of 10 to 15 mi. (18.5 to 27.8 km) or more and where topographic features constrain ground travel. The general problem areas of community noise, air traffic congestion, ground transportation interface, pollution, and safety appear to have workable solutions.

# AN ECONOMIC ANALYSIS OF FUTURE SHORT-HAUL TRANSPORTATION

\*George C. Kenyon  
\*Thomas L. Galloway  
\*\*Hubert M. Drake

\*NASA, Advanced Concepts & Missions Division  
\*\*NASA Ames Research Center  
Moffett Field, California

## Abstract

A simplified economic analysis has been made of one transportation mission: intercity short-haul business passenger travel. The analysis includes both air and ground transportation modes for 1968 based on current mode characteristics, and for 1975 and 1982 based on projected characteristics for two assumed levels of R & D. The effects of changes in the transportation mode and interface characteristics are investigated. The simplified approach allowed a qualitative assessment of the relative merits of transportation modes. Specifically, the results for 1968 indicated that the auto, bus, and subsonic jet were competitive while the train was not. The helicopter could be competitive at ranges between 50 and 150 miles for time values above \$5/hour. The light aircraft was particularly attractive for multiple travelers. Results for 1975 and 1982 indicated that: (1) the auto will remain the major mode for short distances; (2) the bus will remain competitive at low time values; (3) the high speed train will not be competitive unless heavily subsidized; and (4) the STOL transport will be a major transportation mode until it is replaced by the VTOL. An intensive level of R & D effort will be required to produce a competitive VTOL transport by 1982. The light aircraft mode, particularly with STOL performance and multiple travelers, appears very promising.

A PROPULSION STUDY OF HORIZONTALLY-OPPOSED-PISTON  
INTERNAL-COMBUSTION ENGINES FOR  
GENERAL AIRCRAFT

Contract NAS 2-5498

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Report - A Propulsion Study of Horizontally-Opposed-Piston Internal-  
Combustion Engines for General Aircraft

Technical Monitor  
Program Manager

Mark H. Waters  
R. B. Fox

AVCO Corporation  
AVCO Lycoming Division  
Williamsport, Pennsylvania

January 1971

Abstract

The overall purpose of this study is to determine ways and means of decreasing the overall costs of owning and operating a light aircraft. The study pertains to the operational cost as well as the selling price of the typical piston aircraft engine for light aircraft. The light aircraft is taken as any aircraft, single or multi-engine, using engines of 450 horsepower or less. This was presumed to be the case as the study contract specified engines from 150 to 450 horsepower.

PART II - ABSTRACTS

SPACE MISSIONS

# INFORMATION TRANSFER SATELLITE (INFOSAT) CONCEPTS

Contract NAS 2-5571

- Volume I - Summary - Information Transfer Satellite Concept Study (CR 114311)
- Volume II - Technical - Information Transfer Satellite Concept Study (CR 114312)
- Volume III - Appendices - Information Transfer Satellite Concept Study (CR 114313)
- Volume IV - Computer Manual - Information Transfer Satellite Concept Study (CR 114314)

Technical Monitor  
Program Manager

Edgar M. VanVleck  
Patrick Bergin

General Dynamics Corporation  
Convair Aerospace Division  
San Diego, California

May 1971

## Abstract

Under this contract, a needs research was performed on promising future Infosat service to define their detailed functional requirements and systems analyses to identify and explore the broad requirements for corresponding satellite systems requirements. Iterative combination of these two techniques produced a condensed list of desirable, economical future Infosat services. A conceptual system synthesis model was developed to help bridge between needs and technology capabilities by estimating cost, weight, volume, power, etc., of "optimal" systems for each functional service requirement. A separate computer program generates approximately optimal terrestrial networks to compare Infosat systems with terrestrial network alternatives. Information transfer demands were identified, analyzed, and combined into requirements for satellite communication services, for both single and multi-purpose satellite systems. Then detailed analysis of each satellite system determined: (1) total system cost, both ground and space segments; (2) sensitivities to various system tradeoffs; and (3) forcing functions controlling the system variations. The report lists candidate missions recommended for more detailed study, descriptions of conceptual systems designs, and a preliminary identification of the technology developments required to bring these systems to fruition.

# SATELLITES AND AIR POLLUTION: A REVIEW AND SYNTHESIS

Contract NAS 2-5987

Satellites and Air Pollution: A Review and Synthesis (71 SAI-23)

Technical Monitor  
Program Manager

Kenneth F. Sinclair  
Raoul J. Freeman

Systems Applications, Inc.  
Beverly Hills, California

April 1971

## Abstract

This contract addresses itself to the potential interaction of satellites with the world air pollution problem. It is mainly a distillation and synthesis of relevant work done by others on various aspects of the subject. It considers the economic impact of air pollution, promising directions of air pollution research, potential roles for satellites in air pollution research, and the present and potential capabilities of instrumentation suitable for satellite use. The results of the study show that the role of satellites in the understanding and control of air pollution is not clear. It appears that there are certain problems of a global nature for which satellites are ideally suited; however, to derive the most utility from space, it seems prudent to formulate a comprehensive systems approach to the problem, simultaneously utilizing ground, air and space sensors.

# SPACECRAFT COMPONENT SURVIVABILITY DURING ENTRY INTO THE JOVIAN ATMOSPHERE

Byron L. Swenson

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

In response to the concern of the scientific community regarding the possibility of an accidental biological contamination of the middle levels of the atmosphere of Jupiter by components or fragments of an unsterilized spacecraft, an analysis has been made of the survivability of such bodies upon entry along possible entry trajectories. Survivability boundaries are calculated in terms of the body size and the material specific heat capacity and are shown for various average body specific gravities and as a function of entry angle.

NASA TM X-2276, April 1971

# DETERMINE COSTS OF SOLID ROCKET MOTOR BOOSTED S-IVB STAGES

Contract NAS 2-6446

## Summary Report

Volume I - Technical Details

Volume II - Programmatic Details

Volume III - Cost Substantiation

Technical Monitor  
Program Manager

Larry R. Alton  
Robert J. Cielnicky

McDonnell Douglas Astronautics Company  
Huntington Beach, California

December 1971

## Abstract

As a result of program maturity and experience, there is increasing evidence that a solid rocket motor boosted Saturn S-IVB launch vehicle program could be accomplished with lower recurring and non-recurring costs than previously estimated. This configuration is an attractive near-term launch vehicle capable of delivering large payloads at relatively low cost. The objective of this contract was to provide credible detailed cost information necessary for the evaluation of the potential utilization of low cost S-IVB stage boosted by 120" or 156" solid rocket motor clusters. A broad range of vehicle configurations were examined including those with Apollo CSM/LM, Centaur-Viking, and manned reusable glider payloads. Supporting information includes configuration design and performance feasibility, low-cost management and programmatic requirements, cost substantiation and cost sensitivity to changes in design or program requirements.



PERFORMANCE AND COST IMPROVEMENT POTENTIAL OF THE  
120-INCH DIAMETER SOLID ROCKET MOTOR

Contract NAS 2-6330

Volume I - Summary Report - CR 114389

Volume II - Study Approach and Detailed Results - CR 114390

Technical Monitor

Kenji Nishioka

Harry Hornby

Program Manager

J. N. Rossen

United Technology Center  
Sunnyvale, California

December 1971

Abstract

The goal of this contract was to determine extreme performance boundaries of the 120-inch diameter 5 and 7 segment solid rocket motors, their use in clusters as launch vehicle stages, the R&D schedule, and the cost of attaining their performance changes. The performance investigations were categorized into three areas: (1) possible changes to the internal ballistic configuration to meet desired thrust-time profiles without basic hardware changes; (2) changes to thrust-vector-control and/or nozzle concepts (swivel nozzle, straight nozzle or larger expansion ratio nozzle); and (3) relation of clustering hardware weight penalty to number of SRM's in the clustered stages. The R&D schedules for incorporating the changes both individually and in groups and use as launch vehicle stages were also estimated. Non-recurring costs associated with these changes and L. V. stages were estimated along with the recurring costs for several production rates and total SRM's per cluster.

# APPLICATIONS OF NUCLEAR REACTOR POWER SYSTEMS TO ELECTRIC PROPULSION MISSIONS

\*Richard W. Schaupp

\*\*C. D. Sawyer

\*NASA, Advanced Concepts & Missions Division  
Moffett Field, California

\*\*Jet Propulsion Laboratory  
Pasadena, California

## Abstract

The performance of nuclear electric propulsion systems (NEP) has been evaluated for a wide variety of missions in an attempt to establish the commonality of NEP system requirements. Emphasis was given to those requirements and system characteristics that serve as guidelines for current technology development programs. Various interactions and trade-offs between NEP system and mission parameters are described. The results show that the most significant factors in selecting NEP system size are launch mode (direct or spiral escape) and, to a weaker extent, launch vehicle capability. Other factors such as mission, payload, and thrust time constraints, have little influence, thus allowing one NEP system to be used for many missions. The results indicated that a 100kWe NEP would be suitable for most direct escape missions and a 250kWe NEP system would be suitable for more demanding missions that use the spiral escape mode.

Presented at 1971 IEEE Thermionic Conversion Conference, San Diego, California, October 1971

# COMPARATIVE PERFORMANCE OF NUCLEAR AND CRYOGENIC CHEMICAL SPACE PROPULSION SYSTEMS

Duane W. Dugan

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

Solid-core nuclear and cryogenic ( $\text{LH}_2/\text{LOX}$ ) propulsion systems are compared in a generalized way in order to locate boundaries of initial gross mass in Earth orbit and of payload mass that will define the region of performance superiority of one system over the other. Boundaries of equal performance are defined as a function of velocity increment for near-Earth orbital maneuvers for which gravity losses are negligible, and as a function of hyperbolic excess speed for Earth-escape missions in which gravity losses are taken into account. Both single stages and two tandem stages of propulsion are considered. Boundaries are generally defined on the basis of sizing propulsion systems for each requirement of initial mass and velocity change, but the effects of fixing the stages at one size or another is also assessed. The use of a fixed-size nuclear engine (thrust of 75,000 lbf and mass of 25,000 lbm) is included for comparison. The effects of including additional radiation shielding in the nuclear stage for manned applications, however, are shown parametrically, as are the effects of a  $\pm 10$  percent variation about the nominal inert masses of the nuclear system. Also investigated are the effects of specifying that the performance of the nuclear system be greater than that of the chemical system by given factors.

NASA TM X-2352, August 1971

A COMMON SOLAR-ELECTRIC-PROPULSION UPPER STAGE  
FOR HIGH-ENERGY UNMANNED MISSIONS

Contract NAS 2-6040

Volume I - Summary Report - CR 114349  
Volume II - Technical Report - CR 114350  
Volume III - Appendix - CR 114351

TRW Systems Group  
Redondo Beach, California

July 1971

Abstract

The primary objective of this contract is to obtain a conceptual design of a basic solar-powered electrically-propelled upper stage which, with minimum modifications, is capable of performing a large variety of high-energy unmanned missions. Estimates are given of the major costs and program planning requirements involved in the development, production and launch operations of such a stage. The effect of advances in technology are assessed and areas requiring further research are defined.

# A COMPUTER SIMULATION FOR NUCLEAR SPACE POWER SYSTEMS IN PRELIMINARY SYSTEM AND MISSION ANALYSIS

Richard W. Schaupp

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

A computer simulation of nuclear power systems for low-thrust propulsion is described. The computer program is designed to serve as a tool for coupling nuclear system parameters to mission and trajectory analysis and to be useful for preliminary space power systems analysis. Output from the program includes estimates of the major system performance parameters together with weights and geometry. The overall nuclear system is divided into major subsystems; analytical models are developed for each subsystem. The resultant models are normalized to agree with preliminary design data by using normalization parameters external to the actual models. The program treats as variables those nuclear system parameters that interact with the mission, launch vehicle, payload, and trajectory analyses. Simulations are included for various user options including Brayton, Rankine, and thermionic systems, and various radiator configurations, shield designs, dose options, and reactor designs.

Presented at AIAA/SAE 7th Propulsion Joint Specialist Conference,  
Salt Lake City, Utah, June 1971

# AEROSPACE LAUNCH VEHICLE PROGRAM FACTORS, STRUCTURES AND ADVANCED MATERIALS COST-PERFORMANCE TRADE-OFFS

\*Kenji Nishioka  
\*\* N. E. Munch  
\*\*R. B. Bradshaw  
\*\*E. Mangrum

\*NASA, Advanced Concepts & Missions Division  
Moffett Field, California

\*\*General Electric Company  
Apollo Systems  
Daytona Beach, Florida

## Abstract

A parametric investigation of cost-performance trade-offs including program factors and materials and construction technologies have been investigated for a set of representative expendable-type aerospace launch vehicle structural components. The investigation identified those program factors which are the primary cost drivers in the manufacturing operations, e. g. , total quantities produced were found to have the greatest influence on component cost. This was the direct result of high initial costs for facilities and tooling to produce high reliability, minimum weight hardware. Also, advancements in manufacturing technology appear to have little influence on reducing manufacturing costs for future aluminum structures. For the cost-performance trade-offs of materials and construction types, aluminum integrally stiffened skin was used as the baseline material and construction representative materials were chosen to span the advanced material technologies--beryllium and titanium for the metals, boron and carbon fibers in an epoxy matrix for the resin composites, and boron fibers in aluminum matrix for the metallic composites. Primary construction for these advanced materials was honeycomb. The advanced materials structures were lighter, but, with the exception of carbon-epoxy, they were substantially more costly than the baseline aluminum.

Presented at 30th Annual Conference of the Society of Aeronautical Weight Engineers, Inc., Newport Beach, California, May 1971

# UTILIZATION OF JUPITER SWINGBY TRAJECTORIES FOR COMET EXPLORATION

Larry A. Manning

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

Jupiter swingby trajectories are investigated for comet flyby and rendezvous missions. The swingby is shown to result in approach velocities between 0.5 and 6 km/sec for 29 of the 37 short period comets considered. A Titan IIID/Centaur/Burner II launch vehicle will provide a flyby payload of over 2000 pounds for these flybys. Rendezvous missions are defined for four comets (Honda-Mrkos-Pajdusakova, Tuttle-Giacobini-Kresak, D'Arrest and Daniel). The above launch vehicle with a 310 second  $I_{sp}$  upper stage will provide at least a 700 pound payload at each of these comets.

Published in Journal of Spacecraft and Rockets, Vol. 8, No. 11, p. 1152,  
November 1971

# SOME THREE-BODY NUMERICAL SOLUTIONS FOR LOW-THRUST ORBITER MISSIONS

John S. MacKay  
Alfred C. Mascy

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

A velocity-at-the-sphere-of-influence method and an asymptotic matching method of patching together two-body low-thrust solutions are compared to a number of three-body numerical results for outer planet orbiter missions. The two patching methods compare well with the numerical three-body results and do not depend on any particular choice for the size of the sphere-of-influence. The results apply, in a strict sense, only to the operational mode used -- high-thrust terminal retro into orbit. Low-thrust spirals are not considered in the three-body analysis. The terminal low-thrust phase of thrusting is almost entirely reverse to the velocity vector during the planet centered phase of the trajectory. This may lead to important simplifications for low-thrust guidance and navigation procedures.

Published in Journal of Spacecraft and Rockets, Vol. 8, No. 11, p. 1143,  
November 1971



# PRELIMINARY ANALYSIS OF AN ATMOSPHERE-ENTRY PROBE MISSION TO JUPITER

Byron L. Swenson  
Larry E. Edsinger  
Larry A. Manning  
Susan M. Norman  
Kenneth F. Sinclair  
Alan J. Stratton  
Edward L. Tindle

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

The preliminary feasibility of depositing an atmospheric-entry probe from a flyby mission to Jupiter has been examined. This report summarizes the scientific, operational, and system requirements and options for the entry mission. In addition, technological problem areas are indicated. These difficulties and uncertainties do not appear to be insurmountable and the mission should receive careful attention.

NASA TM X-2338, September 1971

# SUPPORT REQUIREMENTS FOR REMOTE SENSOR SYSTEMS ON UNMANNED PLANETARY MISSIONS

\*Contract NAS 2-5647

Volume I - Summary Report  
Volume II - Support Requirements  
Volume III - Appendix A - Support Requirements Summary Tables  
Volume IV - Appendix B - Sensor Scaling Law Computer Program  
Subroutines

Technical Monitor  
Program Manager

Kenneth F. Sinclair  
A. C. Jones

North American Rockwell Corporation  
Space Division  
Downey, California

June 1971

## Abstract

One of the major tasks in planning planetary missions is the definition of experiment payloads and the determination of the support requirements for transport and operation of these payloads. To determine the payloads and their support requirements, it is necessary to have an understanding of the scientific engineering objectives pertinent to a given target, the observation requirements associated with these objectives, knowledge of the operational conditions for a particular encounter, and flexible models of candidate remote sensors capable of meeting all or part of the observation requirements on specific missions. This study was concerned with (1) exploration objectives and observation requirements at Saturn, Uranus and Neptune; (2) development of non-imaging sensor scaling laws; (3) application of imaging sensor scaling laws to flyby missions to Saturn, Uranus and Neptune; (4) application of non-imaging sensor scaling laws to inner and outer planet flyby missions and to inner planet and Jupiter orbiter missions; and (5) definition of compatible imaging, non-imaging and integrated sensor families for selected missions. Results are presented in the form of tables showing all of the important support requirements for pertinent experiments at two different performance levels; i. e. optimal and marginal.

\*These reports conclude Contract NAS 2-5647. Previous reports were published in earlier ACMD publications summaries.

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'QUICKTOP'  
A USER-ORIENTED, MULTI-OPTION, COMPUTER PROGRAM FOR QUICK  
TRAJECTORY AND MASS OPTIMIZATION OF ELECTRIC PROPULSION  
MISSIONS

Alfred C. Masey

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

Abstract

An electric propulsion trajectory and mass optimization computer program is described which has been developed to allow ease of operation, speed of computation, and assurance of a solution. The program determines the performance and system requirements of electrically propelled spacecraft, both solar and nuclear powered, in combination with either specific launch vehicles or assumed shuttle vehicles, and either high- or low-thrust departure or capture stages. The formulation of the logic and optimization techniques is described as well as the functional relationships that define the characteristics of the high- and low-thrust systems. The several output formats, including a trajectory time history, are illustrated, and complete descriptions of all input and output parameters and a program listing in Fortran IV for both IBM and CDC computers are given. The input is simplified by the extensive use of colloquial variables. The program is accurate in simulating entire missions and can quickly define their requirements with relatively short execution times. Example problems are provided which depict the usage of the various options available to the user.

Working Paper MS 71-1, June 1971

PRELIMINARY ANALYSIS OF AN ATMOSPHERE-ENTRY  
PROBE MISSION TO JUPITER

Byron L. Swenson

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

Abstract

The preliminary feasibility of depositing an atmospheric-entry probe from a flyby mission to Jupiter has been examined. This report summarizes the scientific and operational requirements and options for the entry mission. In addition, technological problem areas are indicated. These difficulties and uncertainties do not appear to be insurmountable and the mission should receive careful attention.

Presented at 17th Annual Meeting of the American Astronautical Society,  
Seattle, Washington, June 1971

# EVOLUTIONARY CONCEPTS FOR A NATIONAL SPACE TRANSPORTATION SYSTEM (SHUTTLE)

Edward W. Gomersall  
Darrell E. Wilcox

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

This paper describes the preliminary results of an in-house study of a phased approach to achieving a fully-reusable space shuttle transportation system. The study assumes that a shuttle system is necessary to a viable space program beyond 1980, but recognizes the contingent problem that annual budget limitations may preclude the timely development of the two-stage, fully-reusable shuttle in parallel with other priority space activities. The analysis, therefore, addresses a set of interim "shuttle-like" systems of significantly lower cost which can be efficiently evolved to a fully-reusable space shuttle system later in the program.

Working Paper MO 71-1, May 1971

## STUDY OF AN EVOLUTIONARY INTERIM EARTH ORBIT PROGRAM

Joseph L. Anderson  
Larry R. Alton  
Roger D. Arno  
Jerry M. Deerwester  
Larry E. Edsinger  
Kenneth F. Sinclair  
Edward L. Tindle  
Richard D. Wood

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

### Abstract

This report documents a study of a possible interim Earth orbital manned space flight program that would maintain continuous manned flights between the Skylab I mission and Space Station/Base operation. It considered an evolutionary, gradual, and step-wise spacecraft systems technology development involving four Skylab type mission spacecraft. The missions were evaluated for crews of three, six and nine men and for mission lifetimes of one year. Three- and four-men versions of the Apollo CSM were the logistic vehicles, and these were evaluated with the Titan III-M, Saturn I-B, or Solid Rocket Motored Saturn IV-B as the launch vehicles. A scientific plan was postulated and evaluated for the program. A technical development plan for the life support and electrical power systems was defined so that the components were flown first as experiments, and then, integrated into the later spacecraft as operating systems. The data handling, communications, radiation shielding, micrometeoroid protection, and orbit keeping systems were determined. The program costs were estimated and, excluding operational costs, the cost for each mission would average about \$2 billion. This program as studied would be a viable interim alternative to continue manned Earth orbital flight; however, it would use resources in its development that could not be recovered in the development either of the Space Shuttle or the Space Station/Base.

# SUPPLY AND RESUPPLY OF STATIONS IN SYNCHRONOUS ORBIT

Duane W. Dugan

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

Various methods of using chemical propulsion stages to transport payloads between a low Earth orbit and stations in synchronous (24 hr) orbit are compared. Both one-way and round trips are considered, with one or two stages of expendable or reusable propulsion systems. The problem of disposing of expendable or worn-out reusable stages is discussed and the advantages and disadvantages of using such stages for missions requiring escape from Earth are evaluated. The paper deals chiefly with performance, and does not include quantitative cost comparisons.

Published in Journal of Spacecraft and Rockets, Vol. 8, No. 4, pp. 430-432,  
April 1971



# COMMUNICATIONS IMPLICATIONS OF FUTURE UNMANNED PLANETARY MISSIONS

Kenneth F. Sinclair

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

This paper defines the communications requirements for various levels of mission sophistication to several planetary objectives. These requirements are based on the data loads produced by imaging experiments consonant with the science and engineering objectives pertinent for these missions. Imaging experiments have been emphasized because of their dominant impact on the total data load and data acquisition rate. Operational considerations at each target have also been considered. Missions to Venus, Jupiter and Pluto were selected for analysis since they effectively encompass the wide range of communications problems associated with unmanned planetary missions. These are not presently approved NASA missions but represent possible future missions. The communications data rates required for each experiment class at each target are developed and the communications considerations for S-band, X-band, and 10.6 micrometer laser systems are presented. The paper concludes with a discussion of the transmitter power output requirements with various radio frequency and optical apertures for the experiment programs anticipated at each of the targets.

Presented at International Colloquium on Space and Communications,  
Paris, France, March 1971

## Sample Return Missions to the Asteroid Eros

\*Alfred C. Mascy

\*\*John C. Niehoff

\*NASA, Advanced Concepts & Missions Division  
Moffett Field, California

\*\*Astro Sciences/IIT Research Institute  
Chicago, Illinois

### Abstract

Solar-electric low-thrust and multi-impulse ballistic energy requirements are investigated for sample-return missions to the asteroid Eros. Launch opportunities from 1975 to 1984 are identified. A payload analysis is performed which includes science instrument selection, station-keeping definition and assessment of sample collection requirements. It is concluded that for the favorable 1977 opportunity either a Titan IID/Burner/SEP (10kw) or Titan IID(7)/Centaur/Space Storable (385 sec I<sub>sp</sub>) propulsion system is required to return a 25 kg sample from Eros to a 12<sup>hr</sup> hour earth orbit in a total flight time of three years. Launch range safety and rendezvous communications are identified as problem areas requiring further study.

Presented at Twelfth Colloquium of the International Astronomical Union,  
University of Arizona, Tucson, Arizona, March 1971

# SIZE AND COST FACTORS INFLUENCING THE ATTRACTIVENESS OF NUCLEAR ELECTRIC PROPULSION

Federico G. Casal  
Samuel W. Pitts

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

The economic attractiveness of nuclear electric propulsion systems increases with size. Since our present experience is insufficient to determine whether nuclear electric propulsion is attractive in terms of both performance and economics, a study has been made to identify the conditions under which this might be the case. Probable size-performance relationships were identified for the missions of interest by using scaling laws which are based on physical facts and are consistent with past experience. It is, at present, not possible to determine the sensitivity of cost to the size of the system; therefore, the subject of procurement cost was treated parametrically using the cost of conventional rockets as a means for comparison. It is shown that there are areas of application within which nuclear electric space propulsion appears more attractive than conventional systems in spite of very large ranges of uncertainties in performance and cost.

Presented at AIAA 9th Aerospace Sciences Meeting, New York, New York,  
January 1971

# ESTIMATING OPTICAL IMAGING SYSTEM PERFORMANCE FOR SPACE APPLICATIONS

Kenneth F. Sinclair

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

Frequently, imaging system capabilities must be analyzed in a preliminary fashion to determine the feasibility of future space mission applications and while detailed design considerations are clearly beyond the scope of such a feasibility analysis, the critical system elements must be adequately understood and treated to avoid gross misjudgment. This paper provides an approach suitable for an initial assessment of system performance. Generalized television and photographic imaging systems are developed and the various system elements, such as the lens and film, analyzed. The critical elements are identified and a methodology developed to permit a rapid and systematic estimate of overall system performance.

Working Paper MO 71-3, December 1971

# DATA ACQUISITION SYSTEMS FOR OPERATIONAL EARTH OBSERVATION MISSIONS

Jerry M. Deerwester  
Arthur D. Alexander  
Roger D. Arno  
Larry E. Edsinger  
Susan M. Norman  
Kenneth F. Sinclair  
Edward L. Tindle  
Richard D. Wood

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

This report identifies the data acquisition system capabilities expected to be available in the 1980 time period as part of operational Earth observation missions. By data acquisition system is meant the sensor platform (spacecraft or aircraft), the sensors themselves and the communication system. Results of the study are presented for the most part in parametric form. For each sensor class (i. e., film camera, RBV, multispectral scanner, coherent side-looking radar, etc.) charts are shown that depict swath width and spatial resolution (and, as appropriate, temperature resolution) as functions of the sensor design parameters; projected technology boundaries are also shown. Companion charts of data acquisition rates and spacecraft weights are included. In addition to these sensor-related results, parametric analyses were conducted in the following areas: spacecraft orbit selection, cloud cover effects, aircraft coverage capabilities and communications systems.

Working Paper MO 71-2, November 1971

PART II - ABSTRACTS

OTHER PUBLICATIONS

# A SURVEY STUDY OF TELEOPERATORS, ROBOTICS AND REMOTE SYSTEMS TECHNOLOGY

Arthur D. Alexander, III

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

During September, 1971, the Office of Exploratory Research and Assessment, Research Applications Directorate of the National Science Foundation, requested a ninety-day study of teleoperators, robotics and remote systems technology be undertaken. The purpose of this study was to survey state-of-the-art technology, determine major user needs, and suggest initiatives where federal R&D funding could most significantly impact the application of this technology to the alleviation of explicit national and social problems. The scope of this survey included three important user application areas (medical, mining and oceanography), and a limited survey of teleoperator/robotic subsystems (manipulators, sensors, control and communications).

Working Paper MC 71-1, December 1971

## APPLICATIONS ANALYSIS OF HIGH ENERGY LASERS

Roger D. Arno  
John S. MacKay  
Kenji Nishioka

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

### Abstract

More than a dozen aerospace applications of high power laser systems were examined in varying degrees of detail. Although laser system applications displayed some unique characteristics and capabilities, it became obvious that any large scale replacement of existing systems and methods by lasers would require many simultaneous advances in laser and associated system states-of-the-art. Some of the laser system drawbacks can be countered, however, and several applications appear very interesting. For example, low orbit drag make-up, orbit changing, communications, aircraft power, launch vehicle power, and illumination applications all have promising implications; promising, that is, if the laser generator remains on the ground where its weight is not so important, or if it can be used many times in space so as to amortize its weight.

Working Paper MO 71-4, December 1971



## TELECONFERENCING SYSTEMS

Grant - NGR 05-020-517

Final Report: Teleconferencing: Cost Optimization of Satellite and  
Ground Systems for Continuing Professional Education  
and Medical Services

Technical Monitor  
Program Manager

Edgar M. VanVleck  
Prof. D. A. Dunn  
Prof. B. Lusignan  
Prof. D. Smith

Institute for Public Policy Analysis  
Stanford University  
Stanford, California

December 1971

### Abstract

This grant explored the systems, policy, and user aspects needs to assess the role that information transfer satellites (Infosats) will play in future public services, specifically those that require the interaction of humans and machines to transfer information at a distance, or "Teleconferencing." It lays the groundwork for more comprehensive future analyses by using the important specific cases of continuing professional education and medical services, in several specific regional settings, to validate broad parametric models which can later be used to broaden the analysis and conclusions. It purposely does not attempt to make specific proposals for complete systems to satisfy the given needs. It starts with an intensive survey of the market and demographic aspects of the target user community, including significant legal and policy questions that may be involved in its teleconferencing uses; it explores the critical technical-economic trade-offs and issues involved in relatively "small user" teleconferencing, including ground/satellite system optimization; it examines satellite economics such as the small, dedicated satellite versus the large, multipurpose satellite decision; and it makes detailed comparisons between the various satellite and terrestrial transmission media to determine the lowest cost network for teleconferencing applications.

SYSTEMS AND COST/PERFORMANCE METHODOLOGIES FOR  
OPTIMIZATION OF VEHICLE ASSIGNMENT

Contract NAS 2-5202

Volume I - Final Report - Methodologies for Optimal Resource Allocation  
to the National Space Program and New Space Utilizations  
(NASA CR 114380)

Technical Monitor  
Program Manager

Robert E. Slye  
Larry F. Fox

Lockheed Missiles & Space Company  
Sunnyvale, California

November 1971

Abstract

The optimal allocation of resources to the national space program over an extended time period requires the solution of a large combinatorial problem in which the program elements are interdependent. The developed computer model uses an accelerated search technique to solve this problem. The model contains a large number of options selectable by the user to provide flexible input and a broad range of output for use in sensitivity analyses of all entering elements. Examples of these options are budget smoothing under varied appropriation levels, entry of inflation and discount effects, and probabilistic output which provides quantified degrees of certainty that program costs will remain within planned budget. Also, phase criteria and related analytic procedures were established for identifying potential new space program directions. Used in combination with the optimal resource allocation model, new space applications can be analyzed in realistic perspective, including the advantage gain from existing space program plant and on-going programs such as the space transportation system. The developed model and the new commodity decision criteria can readily be adapted to other resource allocation areas by particularizing parameters and making changes to model analytics.

# SOME CONSIDERATIONS IN THE SELECTION OF AIRCRAFT FOR EARTH RESOURCE OBSERVATIONS

Roger D. Arno  
Jerry M. Deerwester

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

The logistics problems and cost aspects of earth resource surveys using various types of aircraft are discussed. Eight categories of aircraft (from piston engine to large jet) as well as commercial air carriers are examined on the basis of quantity needed, coverage afforded, and annual program cost. Independent parameters in the analysis include (1) the requirements of a typical group of resource features, (2) number and location of bases, (3) cloud cover uncertainty, and (4) aircraft cost and the parametric influence of payload associated costs. The results obtained in this analysis show an advantage in cost and rate of coverage for a special fleet of twin engine turbojets over all other aircraft options. Special fleets of turboprop, large turbojet, piston engine planes and commercial air carriers were found to be inferior, principally because of the greater number of aircraft required to achieve comparable coverage. To illustrate, to cover 45 to 95 percent of the resources considered about every two weeks, the special fleet of twin-engine jets requires 6 to 30 aircraft, while the commercial air carrier numbers range from 36 to 180 for coverage ranging from 40 to 80 percent. Annual program operating costs would appear to run between \$2 and \$10 million plus the costs associated with payload and data handling. Total costs might average between \$10 and \$100 million annually.

NASA TM X-2418, October 1971

# COST ESTIMATION OF RESEARCH AND DEVELOPMENT PROGRAMS

Contract NAS 2-6173

Summary Report - CR 114367  
Final Report - CR 114368

Technical Monitor  
Program Manager

Darrell E. Wilcox  
Richard D. Davison

North American Rockwell  
Los Angeles Division  
Los Angeles, California

September 1971

## Abstract

This contract summarizes the results of the study of cost estimation of research and development (R&D) programs. In this study, a cost data base was developed consisting of the development costs associated with a number of North American Rockwell aircraft. These costs were put into a consistent work breakdown structure format. Special analyses were then conducted to develop cost factors associated with the effect of specifications, with various levels of risk, with business environment considerations, and to evaluate methods of reducing R&D costs. Using the cost data base and the results from the special analyses, cost estimating relationships were developed for the various R&D cost elements. These estimating relationships were then programmed in FORTRAN IV computing language for the IBM System 360 computer. The results of a run of the computer program give a prediction of the development costs of a new aircraft program, based on the design, material, and business environment characteristics associated with the particular aircraft development program. The cost model is built upon a data base derived primarily from a sample of relatively small high-performance, fixed-wing aircraft developed at North American Rockwell during the past several decades. The most appropriate and confident use of the estimating model, therefore, is for new aircraft of this general variety.

# A MODEL FOR ESTIMATING TOTAL PROGRAM COST OF AIRCRAFT, SPACECRAFT, AND REUSABLE LAUNCH VEHICLES

Darrell E. Wilcox

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

A cost model was developed to estimate the cost of RDT&E, fleet acquisition, and operations of aerospace systems. The model was designed for a high degree of flexibility because of its intended application to mission studies of aircraft of all speeds, launch vehicles (airbreathing or VTO rocket), and spacecraft. The model is based on correlation of historical cost data with vehicle design characteristics. Use of the cost estimating relationships requires a knowledge of the weight statement, materials of construction and certain performance characteristics of the vehicle being analyzed. The report describes the cost model in detail and briefly discusses each estimating relationship. The data from which the estimating relationships were developed are illustrated in an Appendix.

Working Paper MA 71-3, August 1971

# COMPUTER PROGRAM FOR ESTIMATING TOTAL PROGRAM COST OF AIRCRAFT, SPACECRAFT, AND REUSABLE LAUNCH VEHICLES

Darrell E. Wilcox

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

## Abstract

A computer program was developed to rapidly generate preliminary estimates of total program cost for mission studies of V/STOL and conventional transport aircraft, hypersonic aircraft, and reusable space transportation systems. The program uses cost estimating relationships (CER's) based on historical cost data for conventional and advanced aircraft, spacecraft, and launch vehicles. The approach is based on correlating cost with parameters such as weight and thrust, and then adjusting the result with complexity factors to account for differences in material and type of construction, performance level, etc. This report briefly describes the computer program and discusses the options available to the user. Included are a definition of the input and output parameters, a program listing, and sample input and output data for a reusable space transportation system.

Working Paper MA 71-2, August 1971

## FORECASTING AND COST ESTIMATING: SOME INTERACTIONS

Larry R. Alton

NASA, Advanced Concepts & Missions Division  
Moffett Field, California

### Abstract

A cost estimate is a particular type of forecast and recently developed forecasting techniques should be useful in developing estimates of future project costs. Current cost estimating methods place emphasis on historical analogy and CER's without considering the change of cost trends with time as technology advances. The new forecasting methods are particularly attractive when the cost estimate is being made for a project which will be completed at least several years in the future, and when the costs involved are changing rapidly. The various methods of exploratory and normative forecasting are described and some advantages, limitations, and interactions identified.

Presented at 15th Annual Meeting and 1st International Cost Engineering Symposium of the American Association of Cost Engineers, Montreal, Canada, June 1971

## CONTEXTUAL PLANNING FOR NASA

Contract NAS 2-5431

Volume I - A Second Workbook of Alternative Future Environments  
for Mission Analysis (HI-1272-IR)

Volume II - Appendix (An Outline of a National Profile)

Technical Monitor  
Program Manager

Jerry M. Deerwester  
Anthony J. Weiner

Hudson Institute, Inc.  
Croton-on-Hudson, New York

April 1971

### Abstract

This contract represented a continued analysis of the environment in which NASA might find itself 5-15 years hence. Volume I addresses primarily international issues with emphasis on the possible character of space programs of other nations between now and 1985. The analysis addresses the questions of the attitudes of the opinion groups within U. S. society toward such programs and, two, what activities might NASA undertake that would enable it to take advantage of opportunities for international cooperation in space and/or meet international space challenges. Volume II is devoted to the domestic social environment. Significant opinion groups in U. S. society are defined. The relative stability of opinions held by these groups are investigated in order to gain insights concerning their future attitudes. Secondarily, the magnitude of such changing attitudes so identified is discussed.



# AEROSPACE STRUCTURAL MANUFACTURING CONCEPTS

Contract NAS 2-5857

- Volume I - Summary - CR 114281
- Volume II - Manufacturing Line Model Descriptions, Analyses, and Results - CR 114282
- Volume III - Survey of Manufacturing Techniques and Factors - CR 114283

Technical Monitor	Kenji Nishioka
	Harry Hornby
Program Manager	Neil E. Munch

General Electric Company  
Daytona Beach, Florida

March 1971

## Abstract

Under this contract, aerospace manufacturing was analyzed using conventional materials (aluminum) to determine and evaluate those parameters having a strong impact on manufacturing technology and cost. Also, a preliminary interaction analysis of the interrelationships between parameters was performed. Industrial and government organizations were surveyed and detailed data were obtained for current and advanced manufacturing technologies and their associated costs. The technical data were used to analytically identify manufacturing lines of varying degrees of advancements (technologies). Costs associated with these manufacturing lines were determined. Two typical aerospace structural components were used as bases for the cost evaluations. Manufacturing cost sensitivities to technology improvements, programmatic changes, production rates, program duration, and capital depreciation methods were also determined.